ELECTRIC MOTOR ASSIST TYPE POWER STEERING APPARATUS

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

The present invention relates to an electric motor assist type power steering apparatus, which assists the steering effort of a driver by making the electric motor power act on a steering system directly.

2. PRIOR ART

An electric motor assist type power steering apparatus (hereinafter defined as an electric power steering apparatus) assists the steering force of a driver by making use of the driving force of an electric motor directly. A vehicle, on which an electric power steering apparatus is mounted, is widely spreads, and according to the electric poser steering apparatus, since a movement of the steering becomes light, a driver operates the steering without strong force.

As an example of the electric power steering apparatus, a pinion assist type electric power steering apparatus, in which a worm shaft and a worm wheel are used as the means for transmitting the driving force of an electric motor, is known. The electric power steering apparatus, disclosed in the Japanese patent unexamined patent publication H11-43062, is one example thereof.

In this electric power steering apparatus, as shown in FIG. 8, an electric motor 51 for adding an assist steering force

to a steering shaft, which is rotated by the operation of the steering, is provided. The worm shaft 52 is connected to the electric motor 51. A pinion shaft 53 is joined with the steering shaft. The worm wheel 54, which is engaged with a worm gear 52A of the worm shaft 52, is fixed to a pinion shaft 53 so that it will be in the coaxial location with respect to the pinion shaft 53.

Both end parts 52B and 52C of the worm shaft 52 are held by ball bearings 55 and 56, respectively. The assist steering force brought by the electric motor 51 is add to the pinion shaft 53 through the worm gear 52A and the worm wheel 54 which are engaged together. By adding this assist steering force, the steering force required for steering operation of a driver is decreased.

In the electric power steering apparatus 50 disclosed in the above described Japanese unexamined patent application, however, both end parts of the worm shaft 52 are rotatably held only by the ball bearing 55 and 56 with backlash.

Since the flexural rigidity (flexural resistance) of the worm shaft 52 is not so high, the flexure of the worm shaft 52 tends to be arisen. When the steering is turned back in the other way while turning in the one direction, since the steering torque sensed by the torque sensor (not shown) decreases, the electric motor 51 is controlled so that the assist steering force will be decreased.

In this case, the steering must be turned back with

smoothly by rotating the electric motor 51 through the worm wheel 54 and worm shaft 52. If the flexure is arising on the worm shaft 52, however, since the bending moment affected to the rotation shaft of the worm gear 52A is decreased by the decreasing of the assist steering force brought by the electric motor 51, the restorative deformation is arisen for correcting the flexure.

Since this restorative deformation acts as an undesirable force and inhibits the rotation of the worm gear 52A, the rotation force from the worm wheel 54 is not smoothly transmitted to the electric motor 51. Thus, the mismatch on the suitable relationship among the torque sensor (not shown), the control unit, and the electric motor 51 is arisen. When the moment of the inertia is add thereto, mismatch is further promoted. Then, the turning back of the steering is disturbed and thus the response of the steering becomes worse.

In the electric power steering apparatus 50, moreover, the clearance which exceeds a predetermined clearance value may be arose between the worm gear 52A and the worm wheel 54 as the occurrence of the flexure of the worm shaft 52. When such clearance arises, the dispensable backlash between the worm gear 52A and the worm wheel 54 becomes larger. Thus, the assist steering force brought by the electric motor 51 cannot be transmitted to the steering shaft completely.

These disadvantages caused by the flexure of the worm shaft 52 will be remarkable when the assist steering force

brought by the electric motor 51 becomes large.

SUMMARY OF THE INVENTION

This is therefore, the present invention aim at providing the electric motor assist type power steering apparatus, preferably the pinion assist type electric power steering apparatus, which can prevent the aggravation of the feeling of the steering by preventing the flexure of the worm shaft, and which can transmit the assist steering force of the electric motor to the steering shaft completely.

For attaining these problems, there is provided an electric power steering apparatus comprising; an electric motor for adding the assist steering force to the steering system, a controller which drives said electric motor, a rack shaft which steers a steered wheel by displacing along the axial direction thereof, a pinion shaft which is engaged with said rack shaft through the rack-and-pinion mechanism, a worm shaft which is rotated by the electric motor, and a worm wheel which is engaged with said worm shaft and is integrally arranged with the pinion shaft, one end part of the worm shaft is joined with the electric motor, and holding means, which holds one end part and another end part of the worm shaft on allowing the rotation thereof, is further arranged.

In the electric power steering apparatus according to the present invention, one end part and another end part of the worm shaft are held without play. The worm shaft, in the

conventional manner, is held with play, thus the flexural rigidity is not so high and the flexure of the worm shaft is easily arisen. On the other hand, the worm shaft, in the present invention, is held without play, thus the worm shaft can be held with high flexural rigidity.

Accordingly, by preventing the occurrence of the flexure of the worm shaft, not only the occurrence of the mismatch caused by the flexure of the worm shaft at the time of turning back of the steering but also the occurrence of the aggravation of the steering feeling are prevented. Thus, the certain transmission of the steering force brought by the electric motor to the pinion shaft can be achieved.

In the electric power steering apparatus, preferably, said holding means is composed of plural ball bearings which hold one end part of the worm shaft, and plural ball bearings which hold the another end part of the worm shaft.

According to this electric power steering apparatus, both end parts of the worm shaft are held without play by plural of ball bearings. Thus, the holding of the worm shaft can be carried out on keeping the rotating condition at the both ends of the worm shaft into the smooth condition. And also the holding of the worm shaft can be carried out using ball bearings, which are general-purpose parts without using the specific parts. Therefore, the contribution to a cost reduction may be attained.

In the electric power steering apparatus, preferably,

said holding means is composed of plural ball bearings which hold the one end part of the worm shaft, and a needle bearing which holds another end par of the worm shaft.

According to this electric power steering apparatus, one end part side of the worm shaft joined with the electric motor is held by the plural of ball bearings. Since one end part of the worm shaft is joined with the electric motor, flexural rigidity in the one end part of the worm shaft is comparatively high, and that of in the another end part becomes low a little.

In the present electric power steering apparatus, therefore, another end part of the worm shaft is held by a needle bearing without play. When the worm shaft is held by the needle bearing without play, since the flexural resistance of the worm shaft in the diameter direction is higher than the worm shaft held by the plural of ball bearings, the flexural rigidity along the worm gear whole may be higher. Thus, the occurrence of the flexure of the worm shaft is thus prevented, and also the occurrence of the feeling gap between in the case the steering is turned back in the anticlockwise direction and in the case the steering is turned back in the clockwise direction can be decreased. Thus, not only the prevention of the aggravation of steering feeling but also the certain transmission of the steering force brought by the electric motor 7 to the pinion shaft 3 are achieved.

In the present invention, furthermore, there is provided an electric power steering apparatus comprising; an electric

motor for adding the assist steering force to the steering system, a controller which drives said electric motor, a rack shaft which steers a steered wheel by displacing along the axial direction thereof, a pinion shaft which is engaged with said rack shaft through the rack-and-pinion mechanism, a worm shaft which is rotated by the electric motor, a worm wheel which is engaged with said worm shaft and is integrally arranged with the pinion shaft, end part holding means which holds the one end part of the worm shaft on allowing the rotation of the worm shaft, and center supporting means which holds the center part in the longitudinal direction of the worm shaft on allowing the rotation of the worm shaft, wherein one end part of said worm shaft is joined with the electric motor.

According to this electric power steering apparatus, about the center part in the longitudinal direction of the worm shaft is supported on allowing the rotation of the worm shaft. Thus, the worm shaft can be made into the rotatable condition, and the occurrence of the flexure of the worm shaft can be prevented. This is therefore, the aggravation of the feeling of the steering is prevented, and the steering force brought by the electric motor can be transmitted to the pinion shaft certainly. According to the center supporting means, the worm shaft is held without arranging the holding means at one end part of the worm shaft, the assembling efficiency of the apparatus as a whole is improved.

In the electric power steering apparatus, preferably,

said center supporting means has urging means which gives the urging force towards the engaging part between the worm shaft and the worm wheel from the opposite direction with respect to the engaging part.

According to the present invention, the urging means which urges the worm shaft to the engaging part side with respect to the worm wheel is arranged. Since the flexure of the worm shaft is prevented, and the worm shaft is pressed to the worm wheel with sufficient force, the clearance between the worm shaft and the worm wheel is maintained within the predetermined range. Thus, the occurrence of the unpleasant backlash between the worm gear and the worm wheel can be prevented, and the certain transmission of the rotation of the worm shaft to the worm wheel can be achieved.

In the electric power steering apparatus, preferably, said center supporting means has a first roller and a second roller which are touched with the worm shaft and press the worm shaft toward the engaging part between the worm shaft and the worm wheel.

According to the present invention, the first roller and the second roller, which are fitted with the worn shaft, is applied to the engaging part between the worm shaft and the worm wheel. Thus, the displacement in the ups-and-downs directions of the worm shaft is restricted, and the worm shaft is applied to the engaging part between the worm shaft and the worm wheel. Since the roller is used, the supporting mechanism with

slightest fiction can be obtained.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a whole block diagram of the electric power steering apparatus according to the first preferred embodiment of the present invention.

FIG. 2 is a plan view of the substantial part of the electric power steering apparatus according to the first preferred embodiment of the present invention.

FIG. 3 is a sectional view along the line X-X in FIG. 2.

FIG. 4A is an explaining view of the model of the beam both ends part of which are held without play, and the bending moment applied to the beam.

FIG. 4B is an explaining view of the model of the beam both ends part of which are held with play, and the bending moment applied to the beam.

FIG. 2 is a plan view of the substantial part of the electric power steering apparatus according to the second preferred embodiment of the present invention.

FIG. 6 is a plan view of the substantial part of the electric power steering apparatus according to the third preferred embodiment of the present invention.

FIG. 6 is a sectional view along the line Y-Y in FIG. 2.

FIG. 8 is a plan exploded view of the substantial part of the conventional electric power steering.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The preferred embodiments of the present invention will now be described by referring to the attached drawings. FIG. 1 is a block diagram of the electric power steering apparatus according to the present invention. FIG. 2 is a plan view of the principal part of the electric power steering apparatus. FIG. 3 is a sectional view along the line X-X in FIG. 2.

As shown in FIG. 1, an electric power steering apparatus 1 according to the present invention has a steering 2. The steering 2 is connected to a pinion shaft 4 through a steering shaft 3. A torque sensor 5 and a torque transmitter 6 are attached to the pinion shaft 4. The torque sensor 5 detects the steering torque add to the steering system. The torque transmitter 6 is an assistor, and connected to an electric motor 7, which adds the assists steering force to the steering system.

A pinion 4A, arranged at the bottom part of the pinion shaft 4, is engaged with a gear rack 8A provided on a rack shaft 8. In this construction, the rotation of the pinion shaft 4 is converted into the displacement in the longitudinal direction with respect to the rack shaft 8, and then a steered wheel 9 and 9 are steered. The torque sensor 5 is connected to a control unit 10, and outputs the toque signal to the control unit 10. The control unit 10 computes the assist steering force using at least the torque signal T outputted form the torque sensor 5, and outputs the electric motor control signal VO to

the electric motor 7, and thus the electric motor 7 is controlled.

As shown in FIG. 2 and FIG. 3, the torque transmitter 6 has a worm wheel 11, which is fixed to the pinion shaft 4 so that it might be in the coaxial location with respect to the pinion shaft4. A worm shaft 12 is joined to the rotation shaft of the electric motor 7 through the coupling and the like. A worm gears 12A provided on the worm shaft 12 is engaged with the worm wheel 11.

When the worm shaft 12 is rotated by the actuation of the electric motor 7, the worm wheel 11 engaged with the worm gears 12A is rotated, and thus the pinion shaft 4 is rotated along with the rotation of the worm wheel 11 through the mechanism such as a planetary gear and the like. The assist steering force (steering force) brought by the electric motor 7 is transmitted to the pinion shaft 4, and then transmitted to the steering shaft 3 through the pinion shaft 4.

One end part 12B of the worm shaft 12 is held by a first ball bearing 14A and a second ball bearing 14B, which are arranged in the adjoining location along the longitudinal direction of the worm shaft 12, on allowing the rotation of the worm shaft 12.

The ball bearings 14A and 14B are a holding means, which holds the one end part 12B of the worm shaft 12 with sufficient flexural rigidity. In other words, the holding means restricts the flexure of the worm shaft 12.

Another end part 12C of the worm shaft 12, furthermore, is held by a first ball bearing 15A and a second ball bearing 15B, which are arranged in the adjoining location along the longitudinal direction of the worm shaft 12, on allowing the rotation of the worm shaft 12.

The ball bearing 15A and 15B are also a holding means, which holds the one end part 12C of the worm shaft 12 with sufficient flexural rigidity. In other words, the holding means restricts the flexure of the worm shaft 12.

The location interval L1 between the ball bearing 14A and 14B and the location interval L2 between the ball bearing 15A and 15B are same. The location interval L1 and the location interval L2 are established as long as possible so that it can restrict the flexure of the worm shaft 12 efficiently.

The explanation about the function and the operation of the electric power steering apparatus having the above-described construction will be carried out.

When the driver operates the steering 2 shown in FIG 1, the torque sensor 5 detects the steering torque. The steering torque detected by the torque sensor 5 is output to the control unit 10 as a torque signal T.

In the control unit 10, the assist steering force, which is brought by the electric motor 7 and add to the steering system, is computed using at least the steering torque represented by the torque signal T on considering the factors such as traveling speed and the steering angle.

Based on this computed assist steering force, the electric motor control signal Vo is output to the electric motor 7 from the control unit 10.

The electric motor 7 is driven by the electric motor control signal Vo, and rotates the worm shaft 12 of shown in FIG. 2. One end part 12B of the worm shaft 12 is held by the ball bearing 14A and 14B while the worm shaft 12 is rotating. Another end part 12C of the worm shaft 12 is also held by the ball bearing 15A and 15B. Thus, both end parts of the worm shaft 12 is in the held condition by holding both end part 12B and 12C of the worm shaft 12 on allowing the rotation of the worm shaft.

The explanation about the flexural resistance of the worm shaft 12 will be carried out on considering the worm shaft 12 as a beam.

FIG. 4A is an explaining view of the bending moment in the case that the force P is applied to the center in the longitudinal direction of a beam from the upper direction, wherein both end parts of the beam are rigidly held without play (play means it has a loose fit).

FIG. 4A is an explaining view of the bending moment in case that the force P is applied to the center in the longitudinal direction of a beam from the upper direction, wherein both end parts of the beam are held with play (play means it has a loose fit).

As shown in FIG. 4A, in the case of the beam H, which has

a length l and both end parts HA and HB of which are rigidly held without play, the bending moment add thereto is Pl/8.

As shown in FIG. 4B, in the case of the beam H, which has a length l and both end parts HA and HB of which are held with play, the bending moment add thereto is Pl/4.

The bending moment applied to the beam H, both end parts HA and HB of the which are rigidly held without play, becomes one half in the case that both end parts HA and HB of the beam H are supported with play. Thus, when both end parts HA and HB of the beam H are rigidly held without play, the bending moment might be smaller than the case where both end parts HA and HB are supported with play.

When the force P is applied to the center in the longitudinal direction of the beam H from the upper direction, wherein both end parts of which HA and HB are rigidly held without play, the maximum flexural amount (δ.max) of the beam H is formulated as formula (1).

$$\delta.max = Pl^3/192EI_z \quad (1)$$

P: the force added to the beam H

l: the length of the beam H

E: Young's modulus

I_z: geometrical moment of inertia

On the contrarily, when the force P is applied to the center in the longitudinal direction of the beam H from the upper direction, wherein both end parts of which HA and HB are held with play, the maximum flexural amount (δ.max) of the beam

H is formulated as formula (2).

$$\delta_{.}max = Pl^3/48EI_z \qquad (2)$$

P: the force applied to the beam H

l: the length of the beam H

E: Young's modulus

I_z: geometrical moment of inertia

Therefore, the flexural amount of the beam H, wherein both end parts are rigidly held without play becomes to one fourth with respect to the case where both end parts are held with play. As described above, when both end parts HA and HB of the beam H are rigidly held without play, the flexural amount of the beam H can be smaller than that of the beam H, both end parts of which are held with play. The beam with sufficient flexural rigidity and with high flexure resistance can be supplied when both end parts of the beam are held without play.

Therefor, when both end parts of the beam H are rigidly held, the holding of the beam member can be carried out with sufficient rigidity than the case where the both end parts are supported with play, and thus the maximum flexural amount of the beam H can be smaller.

As for the electric power steering apparatus 1 according to the present preferred embodiment, the worm shaft 12 is rigidly held by the ball bearing 14A, 14B, 15A and 15B without play. Since the same reason as described in the case of beam H can be applicable, the worm shaft 12 according to the present invention can be held with sufficient flexural rigidity as

compared to the conventional holding manner.

When the force P is applied to the center in the longitudinal direction of the worm shaft 12 as a result of the actuation of the electric motor 7, therefore, the bending moment becomes to one half and the maximum bending amount becomes one fourth. Thus, the flexure of the worm shaft 12 is efficiently prevented.

Then, the occurrence of the mismatch, which is caused by the flexure of the worm shaft at the time of the steering wheel is turning back in the reverse direction, and the aggravation of the steering responsibility in the electric power steering apparatus 1 are sufficiently prevented. Thus, the transmission of the assist steering force brought by the electric motor 7 to the steering shaft 3 can be achieved.

In the present embodiment, furthermore, due to the weight of the electric motor 7, the difference between the flexural rigidity at one end part 12B and at the another end part 12C of the worm shaft 12 may be arisen.

When the rotation axis of the electric motor 7 and the worm shaft 12 are joined firmly, for example, the flexural rigidity at the one end part 12B of the worm shaft 12 is higher than another end part 12C of the worm shaft 12 (flexural angle becomes smaller).

If the rotation axis of the electric motor 7 and the worm shaft 12 are joined firmly, it is acceptable that the location interval L2 between the ball bearing 15A and 15B, which support

another end part 12c of the worm shaft 12, is established wider than the location interval L1 between ball bearing 14A and 14B.

To be more precise, the flexural rigidity of another end part 12c side can be stronger than that of one end part 12B side, by establishing the interval between the ball bearing 15A and 15B wider than that of between the ball bearing 14A and 14B. Therefore, since one end part 12B and another end part 12C are rigidly held with the uniform flexural rigidity depending on the strength of the connecting part between the rotation axis of the electric motor 7 and the worm shaft 12, the prevention of the flexure of the worm shaft 12 can be achieved more certainly.

The second preferred embodiment according to the present invention will be described. Fig. 5 is a plan sectional view showing a substantial part of the electric power steering apparatus according to the present invention.

In an electric power steering apparatus 20 according to the present preferred embodiment, only the construction of the torque transmitter is differing from the electric power steering apparatus 1. Thus, in the following explanation, the explanation is mainly carried out about the different components, and the same components as that of explained in the first embodiment is emitted and indicates as the same symbol.

As shown in FIG. 5, a torque transmitter 21 according to the present second preferred embodiment of the electric power steering apparatus 20, has a worm wheel 11 fixed to the pinion

shaft 4 so that it might be in the coaxial location with respect to the pinion shaft 4.

A worm gear 12 is joined to the electric motor 7. The worm gears 12A provided to the worm shaft 12 is engaged with the worm wheel 11.

When the worm shaft 12 is rotated by the actuation of the electric motor 7, the worm wheel 11 engaged with the worm gears 12A is rotated, and then the pinion shaft 4 is rotated along with the rotation of the worm wheel 11. The assist steering force brought by the electric motor 7 is transmitted to the pinion shaft4. These compositions are same as that of disclosed in the first preferred embodiment.

One end part 12B of the worm shaft 12 is held by the ball bearing 14A and 14B which are arranged in the adjoining location along the longitudinal direction of the worm shaft 12.

On the other hand, another end part 12C of the worm shaft 12 is held by a needle bearing 22 on allowing the rotation around the axis. The electric power steering apparatus 20 according to the present preferred embodiment differs in that the another end part 12C of the worm shaft 12 is supported without play on allowing the rotation.

As for the worm shaft 12 in the electric power steering apparatus 20 according to the present preferred embodiment, one end part 12B of the worm shaft 12 is held without play by the two of ball bearings 14A and 14B, and another end part 12C of the worm shaft 12 is held without play by the needle bearing

22.

As for the needle bearing 22, since needle rollers (located at inner-side and outer-side in figure) are contacting with the worm shaft 12 along the longitudinal direction of the worm shaft 12, wide range of the worm shaft 12 is held by the needle roller.

Thus, flexural resistance in the diameter direction at the another end part 12C of the worm shaft 12 where is supported by the needle bearing 22 is higher than one end part. Therefore, since another end part 12C is held by the needle bearing 22, the flexural rigidity at the another end part 12C of the worm gear 12 is also higher than the one end part 12B where the worm gear 12 is held by the ball bearing 14A and 14B.

The flexural rigidity at one end part 12B and another end part 12C of worm shaft 12 can be uniform by holding the another ends part 12C using the needle bearing 22, which gives the superior flexural resistance, even if the rigidity at the one ends part 12B becomes high as a result of the firmly connection between the rotating shaft of the electric motor 7 and the worm shaft 12.

The occurrence of the flexure of the worm shaft is thus prevented, and also the occurrence of the feeling gap between in the case the steering is turned back in the anticlockwise direction and in the case the steering is turned back in the clockwise direction can be decreased. Thus, not only the prevention of the aggravation of steering feeling but also the

certain transmission of the steering force brought by the electric motor 7 to the pinion shaft 3 are achieved.

The third preferred embodiment of the present invention will be explained. FIG. 6 is a plan sectional view of the substantial part of the electric power assist type steering apparatus according to the present invention. FIG. 7 is sectional view along the line Y - Y in FIG 6.

In the electric power steering apparatus 30 according to the present preferred invention, only the construction of the torque transmitter is differing from the electric power steering apparatus 1. Thus, in the following explanation, the explanation is mainly carried out about the different components, and the same components as that of explained in the first embodiment is emitted and indicates as the same symbol.

As shown in FIG. 6, a torque transmitter 21 according to the present second preferred embodiment of the electric power steering apparatus 30, has a worm wheel 11 fixed to the pinion shaft 4 so that it might be in the coaxial condition with the pinion shaft 4.

The worm gear 12 is joined to the electric motor 7, and a worm gear 12A provided thereto is engaged with the worm wheel 11.

When the worm shaft 12 is rotated by the actuation of the electric motor 7, the worm wheel 11 engaged with the worm gear 12A is rotated, and then the pinion shaft 4 is rotated along with the worm wheel 11. The assist steering force brought by

the electric motor 7 is transmitted to the pinion shaft4. These compositions are same as that of disclosed in the first and second preferred embodiment.

One end part 12B of the worm shaft 12 is held by a ball bearing 32 in the condition the rotation of the worm shaft 12 might be allowed. Another end part 12C is also held by a ball bearing 33 in the condition where the rotation of the worm shaft 12 might be allowed.

A central holding means 35 is arranged at the almost central part in the longitudinal direction of the worm shaft 12. The central holding means 35 is positioned so that the worm shaft 12 might be sandwiched between the worm wheel 11 and the central holding means 35, and has a urging means 34 which crowds the worm shaft 12 toward the direction of the worm wheel 11.

According to this urging means 34, the worm shaft 12 is pressed toward the worm wheel 11 from the opposite direction side with respect to the engaging part where the worm gear 12A and worm wheel 11 are engaged together. This urging means 34 is arranged for pressing the worm shaft 12 to the engaging part of the worm wheel 11, and is composed of a spring 36, an upper roll 37, a lower roll 38, and a roller holder 39 (see FIG.7).

As shown in FIG. 7, the urging means 34 has the upper roll 37 and the lower roll 38 which are arranged at the opposite side with respect to the engaging part where the worm wheel 11 and the worm gear 12A of the worm shaft 12 are engaged together. The urging means 34 also has a roller holder 39, which rotatably

supports the upper roll 38 and the lower roll 39, and the spring 36, which press the roller holder 39 towards the worm shaft 12 urgently.

The upper roll 37 and the lower roll 38 are fit with the worm gear 12A, respectively, and transmit the urgent force brought by the spring 36 to the worm gear 12A. The rotation shafts of the upper roll 37 and the lower roll 38 are supported by the roller folder 39 and thus the movement in the ups-and-downs directions thereof is restricted.

In the electric power steering apparatus 30 according to the present preferred embodiment, about the center part in the longitudinal direction of the worm shaft 12 is supported by the center holding means 35. The flexural degree of the worm shaft 12, conventionally, tends to be maximum at the central part in the longitudinal direction of the worm shaft 12. As for the present preferred embodiment, since the worm shaft 12 is supported by the center holding means 35, the occurrence of the flexure of the worm shaft 12 is efficiently prevented. As a result of this prevention, the aggravation arose at the time of turning back of the steering is prevented, and thus the prevention of the aggravation of the steering feeling and the certain transmission of the steering force by the electric motor to the pinion shaft can be achieved.

In the present invention, the central part between one end part and the another end part of the worm shaft 12 is supported, the scattering in the flexural resistance in the

longitudinal direction of the worm shaft 12 can be smaller. Thus, the gaps in the steering feeling depending on the turning direction of the steering can be smaller.

As for the present invention, furthermore, since the center holding means 35 has the urging means 34, the urgent force brought by the spring 36 is transmitted to the worm shaft 12 through the upper roll 37 and the lower roll 38. Accordingly, the clearance between the worm gear 12A and the worm wheel 11 is maintained within the predetermined clearance even if the clearance, which exceeds a predetermined clearance value, come close to arising as a result of the occurrence of slight flexure of the worm gear 12.

The worm gear 12A and the worm wheel 11 are certainly engaged together by the center holding means 35, the unpleasant backlash between the worm gear 12A and the worm wheel 11 thus can be prevented. Then, the transmission of the assist steering force brought by the electric motor 7 to the worm wheel 11 through the worm shaft 12 can be achieved certainly.

Since the urgent force brought by the spring 36 is transmitted to the worm shaft 12A through the upper roll 37 and the lower roll 38 which are being rotatable, the rotation of the worm shaft 12 is carried out without any restriction.

The displacement in the ups-and-downs directions of the upper roll 37 and the lower roll 38, which are applied to the worm shaft 12, are restricted, furthermore, the displacement in the ups-and-downs directions of the worm gear 12 is also

prevented.

According to this prevention, the flexure in the ups-and-downs directions of the worm gear 12 is also prevented. Thus, the aggravation of the steering feeling is prevented, and also the steering force, which is brought by the electric motor, is certainly transmitted to the pinion shaft. According to the supporting mechanism of the present invention, since the worm gear 12 supported by the upper roll 37 and lower roll 38, the supporting mechanism with reduced unpleasant friction can be supplied.

In the present preferred embodiment, both end parts of the worm gear 12 are held by the ball bearings 32 and 32, but the holding manner of the worm gear 12 is not restricted to this case. The holding manner, for example, in which the worm gear 12 is held without the ball bearing arranged at another end part of the worm gear can be applicable as long as the flexural resistance brought by the center holding means is acceptable.

In the present preferred embodiment, the explanation about the electric power steering apparatus, which assist the steering effort of the driver by adding the assist steering force brought by the electric motor in addition to the steering force brought by the driver's operation, is carried out.

The application of the present invention is not restricted to the above-described case. The application to the another type of construction may be acceptable as long as the it has a construction that the diving force brought by the

electric motor is add to the pinion shaft, which is joined to the rack shaft and steers the steering wheel. As an example of this, the steer-by-wire mechanism which steers the steered wheel only by the driving force, which is brought by the electric motor and is controlled by the electric signal, and the four-wheel-steering mechanism and the like are considerable.

As described above, in the present invention, the worm shaft 12 is held with sufficient flexural rigidity by holding the worm shaft without play. According to this invention, since the flexure of the worm shaft 12 is prevented, the aggravation caused by the flexure of the worm shaft 12 at the time of turning back of the steering is prevented. As a result of this prevention, the aggravation of the steering feeling and the certain transmission of the steering force, which is brought by the electric motor, to the pinion shaft can be achieved.

In the present invention, one end part and another end part of the worm shaft are held by plural of ball bearings, respectively. According to this invention, the worm shaft is held without play on maintaining the smooth rotation of the worm gear. Since the ball bearing which are general-purpose components is used, furthermore, it can contribute to a cost reduction.

In the present invention, both end parts of the worm shaft are held with the uniform flexural rigidity by holding the another end part side, in which the flexural rigidity is low

a little, by the needle bearing. According to this invention, the flexure of the worm shaft is certainly prevented and also the occurrence of the feeling gap between in the case the steering is turned back in the anticlockwise direction and in the case the steering is turned back in the clockwise direction can be decreased. the certain transmission of the steering force brought by the electric motor 7 to the pinion shaft 3 is achieved.

In the present invention, the occurrence of the flexure of the worm shaft can be prevented while the worm shaft is made into the rotatable condition. According to this invention, the aggravation of the steering feeling and the certain transmission of the steering force brought by the electric motor to the pinion shaft can be achieved.

In the present invention, since the worm shaft is pressed to the engaging part between the worm shaft and the worm wheel by the urgent force of the urging means with the suitable force, the clearance between the worm shaft and the worm wheel can be maintained within the predetermined ranges. According to the present invention, since the occurrence of the backlash between the worm gear and the worm wheel is prevented, the rotation of the worm shaft is certainly transmitted to the worm wheel .

In the present invention, the displacement in the ups-and-downs directions of the worm shaft is restricted. The worm shaft is crowed toward the engaging part with worm wheel on allowing the rotation of the worm shaft. According to the

invention, since the roller is used, the unpleasant friction with respect to the worm gear can be reduced.